

SCIENCE FOR CERAMIC PRODUCTION

UDC 546.621'21':66.087.9

SPECIFICS OF ELECTROPHORETIC PRECIPITATION OF ALUMINUM OXIDE

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The possibility of obtaining a uniform aluminum oxide precipitate of sufficient thickness from its suspension in an aqueous medium with an electrolyte additive is considered. The effect of the concentration and type of electrolyte on the thickness, moisture, specific output, and rate of sedimentation of the precipitate is demonstrated.

Finely disperse powder materials are widely used in contemporary technologies. Electrophoretic precipitation of aluminum oxide powders from aqueous media is a relatively new method. This method makes it possible to obtain high-quality layers of a uniform thickness with a high precipitation rate. The layer thickness in this case can be easily controlled within preset limits [1]. The production of uniform coatings based on aluminum oxide by electrophoresis is of interest regarding some issues of the technology of ceramic molds. Besides the high quality of the precipitate, electrophoretic precipitation provides for a high degree of control of the process within wide parameter intervals, which makes it possible to automate the process of making ceramic molds.

The present study is dedicated to studying the possibility of obtaining aluminum oxide precipitates from an aqueous medium using the electrophoretic method.

The quality of electrophoretic precipitate depends on the conditions of the process, on applied voltage, as well as on the composition and concentration of suspension and the type and concentration of electrolyte.

In a highly polarized medium, it is impossible to use high external voltage due to the intensity of undesirable side processes in electrolysis. Therefore, the main method for producing a precipitate of high thickness is to prepare a suspension with high electrophoretic mobility, i.e., particles of finely disperse material should carry a rather high electric charge (ξ -potential). Charging of disperse particles surface by means of selective adsorption of the respective ions is provided by the presence of a potential-forming electrolyte in the suspension [2].

The present study investigates the effect of the main component of the electrophoretic suspension, i.e., of the electrolyte, on the thickness and moisture of the resulting precipitate and on the rate of precipitation of aluminum oxide particles from the suspension.

Electrophoretic precipitation of aluminum oxide from a suspension containing an electrolyte additive was implemented on a metal substrate surface (a metal plate with a surface area of 25 cm²). If electrophoresis takes place in such a system and aluminum oxide particles are deposited on the anode (anaphoresis), there is a certain negative charge on Al₂O₃ particles. In this case, the electrolyte anions are potential-forming ions. The size of Al₂O₃ particles ranged from 1 to 10 μ m. The content of Al₂O₃ powder in the suspension was constant and amounted to 60% (1.5 kg of the dispersion phase per 1 liter of the dispersion medium). The experiments were carried out in the following order: the suspension was prepared in one vessel and then poured into several vessels in coordination with the concentration of the particular type of electrolyte. The quantity of electrolyte varied from 0.05 to 0.35% with an interval equal to 0.025% of the electrolyte content (the weight content relative to the dispersion phase weight).

Three type of electrolytes were tested:

- (1) electrolyte with a monovalent anion $\text{KH}_2\text{PO}_4 \cdot 3\text{H}_2\text{O}$;
- (2) electrolyte with a bivalent anion $(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$;
- (3) electrolyte with a tetravalent anion $\text{Na}_4\text{P}_2\text{O}_7 \cdot 3\text{H}_2\text{O}$.

Metal plates (an anode and a cathode, surface area 25 cm²) were placed into an electrophoretic bath. A constant voltage of 60 V was supplied to the electrodes. The distance between the electrodes was 0.05 m. The duration of precipi-

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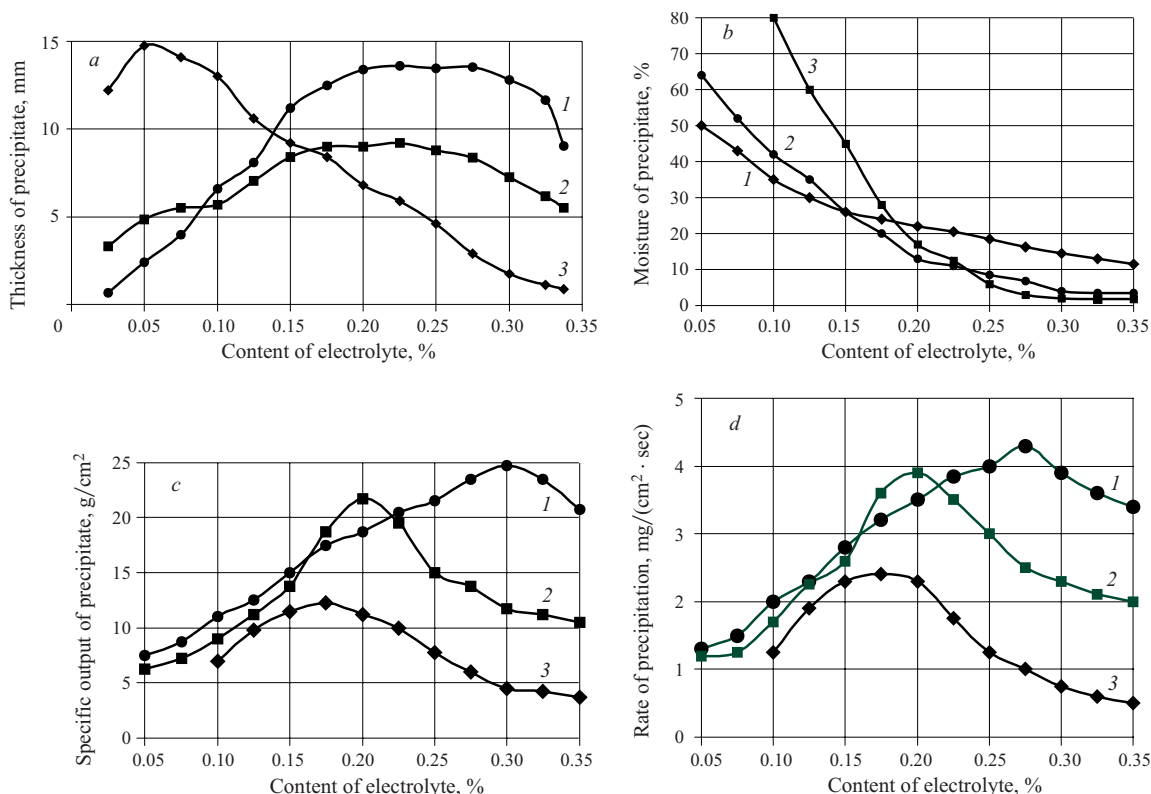


Fig. 1. The effect of content and type of electrolyte on thickness (a), moisture (b), specific output (c), and precipitation rate (d) of electrophoretic precipitate: 1, 2, and 3) electrolyte with mono-, bi-, and tetravalent anions, respectively.

tate formation was 180 sec. These parameters were constant in all experiments. The obtained precipitate was weighed, dried to a constant mass, and weighed again. All experiments were carried out at a temperature of 298 ± 5 K.

The concentration of electrolyte and its type have a significant effect on electrophoretic precipitation [3]. Figure 1a shows the dependence of precipitate thickness on the content of electrolyte in the suspension.

Under low concentrations of electrolyte 1, the thickness of the precipitate monotonically increases until a content of electrolyte about 0.2%. An increase in its content to 0.3% does not produce an increase in thickness, and a further increase in the concentration of electrolyte decreases the thickness of the resulting precipitate. In using electrolyte 2, the type of the dependence is similar, but the absolute thickness of the resulting precipitate is about 1.5 times smaller.

In adding electrolyte 3, the precipitate thickness maximum is sharply shifted toward the lowest concentrations. In contrast to electrolytes 1 and 2, the introduction and increase in electrolyte 3 correlate with a perceptible decrease in the thickness of the precipitate. It should be noted that the optimum concentration and reproducibility of precipitate thickness correlate with the following content levels: 0.175–0.300% for electrolyte 1 and 0.175–0.250% for electrolyte 2.

In introducing electrolyte 3, the maximum thickness of the precipitate correlates only with a value equal to 0.05%. On further increase in concentration, the precipitate thickness sharply decreases. Apparently, adding a polyvalent anion increases the electrokinetic potential of particles, which leads to a higher rate of electroprecipitation and denser packing of the precipitate and, accordingly, to a smaller thickness of the precipitate. As the concentration increases, a similar process is observed but proceeding at a much slower rate.

It should be noted that the increase in the precipitate packing density and the decrease in its thickness as a function of the growing concentration and valence of the anion is corroborated by the decreasing moisture of the resulting precipitate (Fig. 1b). One can observe a general regularity: as the concentration of the electrolyte increases, the moisture of the precipitate decreases monotonically.

An increase in the valence of the anion leads to a sharper decrease in moisture with increasing concentration. A study of the thickness and moisture of the precipitates demonstrated that the optimum moisture correlated with the optimum thickness of the precipitate. However, the selected optimum values primarily depend on requirements imposed on the precipitate [4].

The specific output of the precipitate depends on its thickness and moisture. The greater the thickness and the lower the moisture, the higher the specific output of the pre-

cipitate. It should be taken into account that in the case of low moisture, the precipitate may crack and crumble in drying.

Figure 1c shows the relationship between the specific output of the precipitate and the concentration and type of electrolyte. In this case the relationship has a slightly different shape with a clearly expressed maximum. Under a certain concentration of electrolyte, the dependences of the rate of electrophoretic precipitation (Fig. 1d) have the same shape as seen in the specific output dependence.

In conclusion it should be noted that a general phenomenon observed in adding electrolytes of all three types is intense sedimentation of aluminum oxide particles in the considered suspensions.

Thus, the possibility of obtaining uniform precipitates of aluminum oxide of sufficient thickness from Al_2O_3 suspensions using the electrophoretic method in an aqueous medium with an electrolyte additive is demonstrated.

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